Quantifying the contribution of different cloud types to the radiation budget in southern West Africa during the monsoon season

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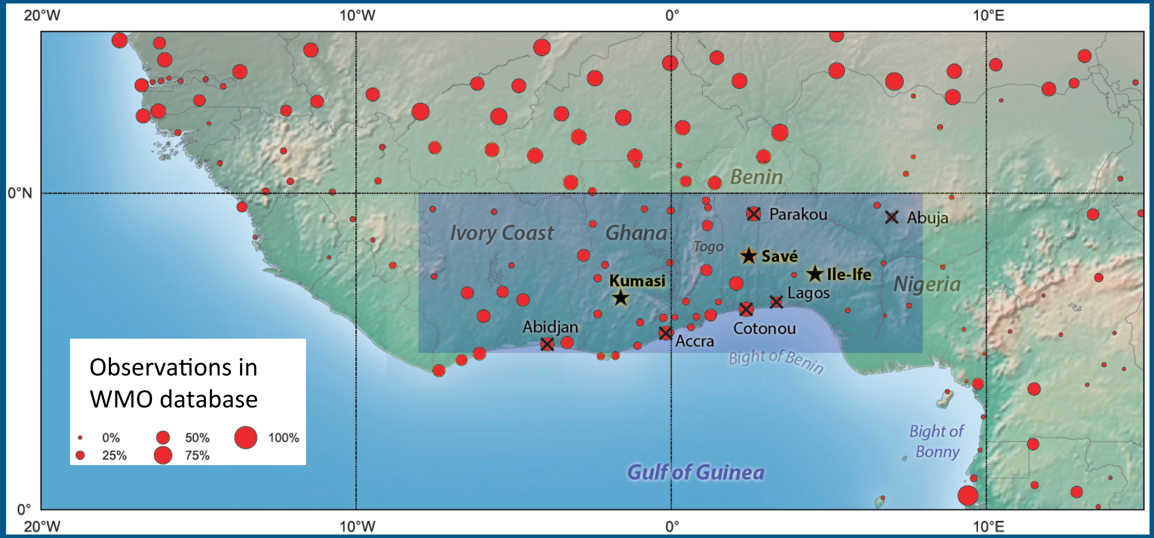
Why southern West Africa (SWA) during monsoon season?

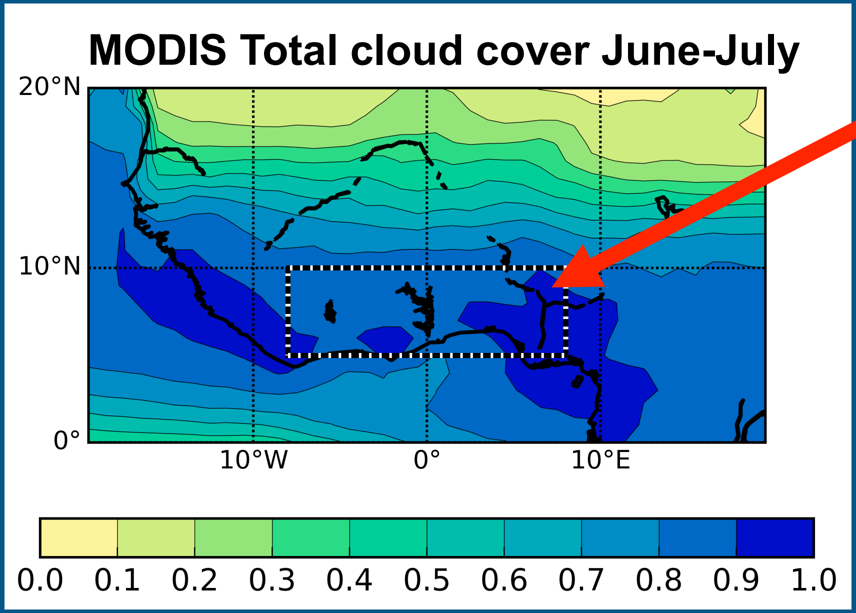


DACCIWA
Dynamics-aerosol-chemistry-cloud interactions in West Africa

Knippertz et al. (BAMS, 2015)

- Monsoon: June-September, SWA: 8W-8E, 5-10N
- Large vulnerable population (~350 m) increasing rapidly.
- Exposed to changes in uncertain monsoon rainfall.
- Increasing anthropogenic emissions
- Complex cloud, lack of observations – poorly understood.

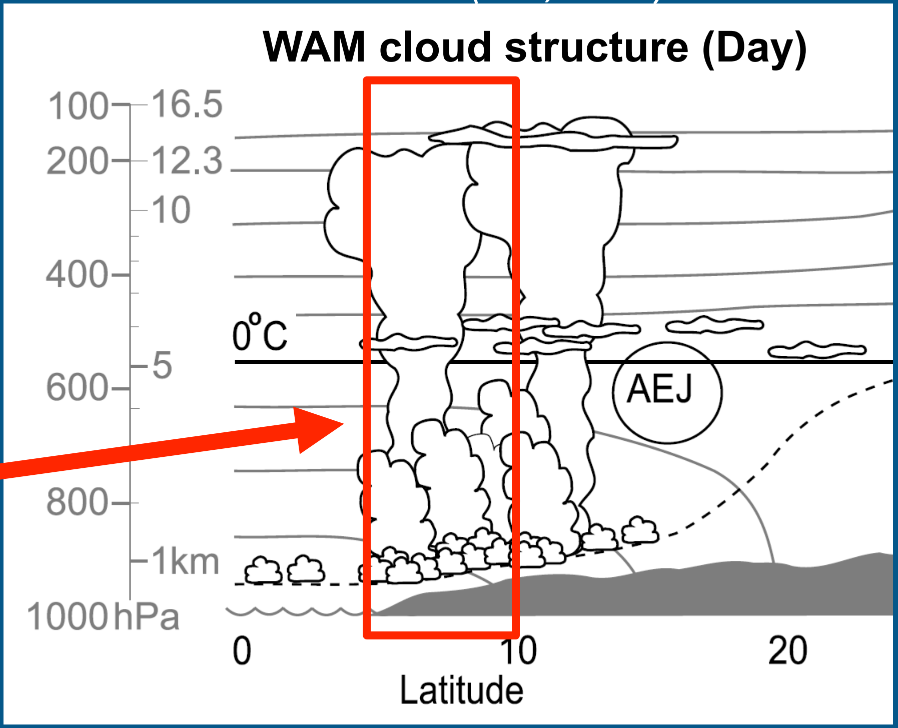
Complex vertical cloud structure in SWA during monsoon season.



Hill et al. (JGR, 2016)

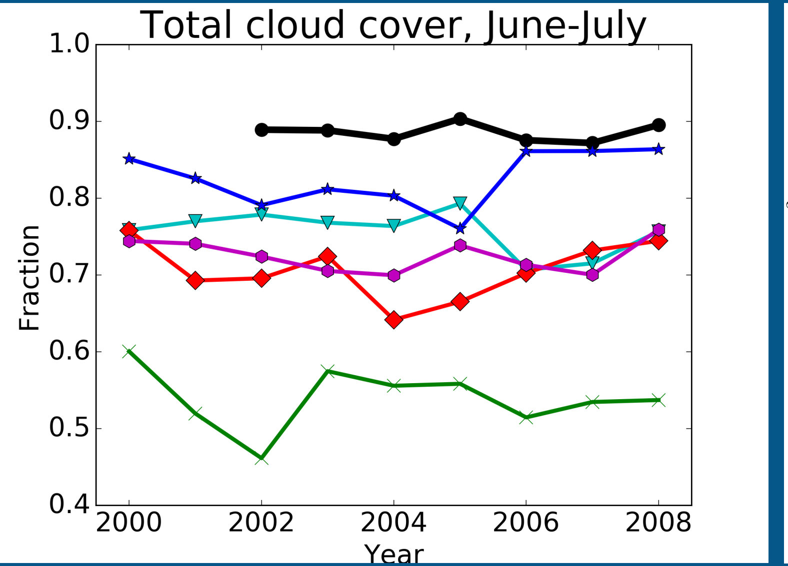
Very cloudy during Monsoon season

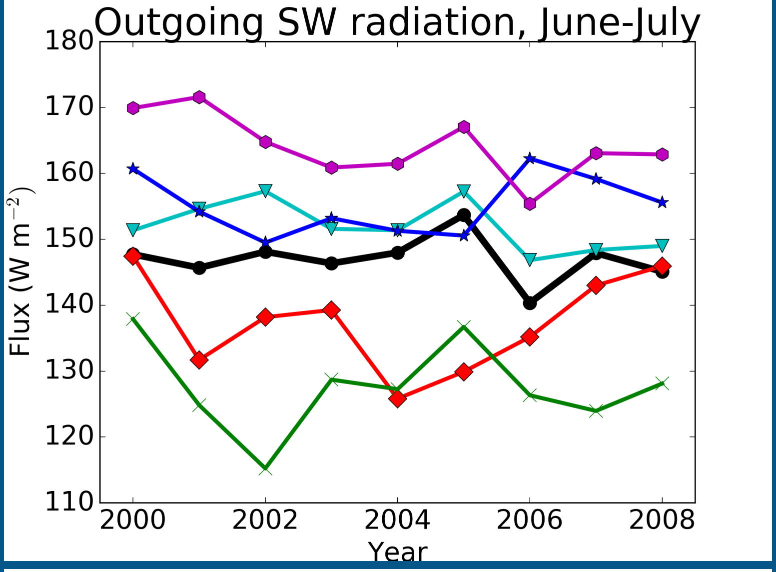
Stein et al. (JGR, 2011)



Many different cloud types occur

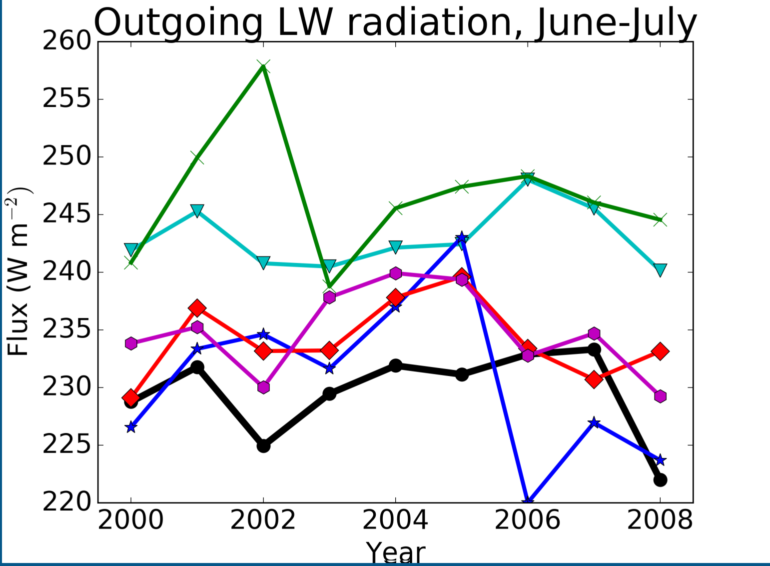
Large cloud and radiation errors in SWA in climate models





Good agreement between CERES and GERB

Large spread in CMIP5 atmosphere only models



Large spread in vertical distribution of cloud cover in climate models

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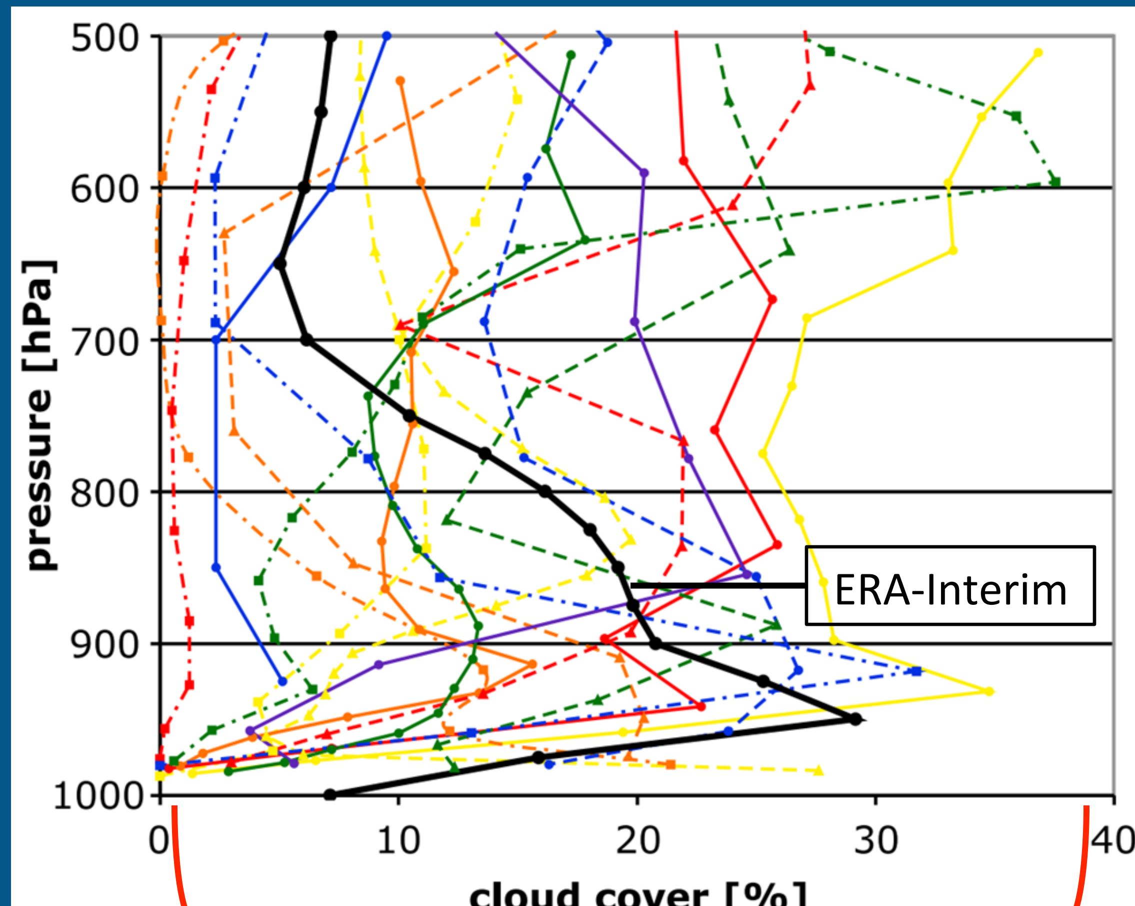
July – September

6-10N, 7W- 7E

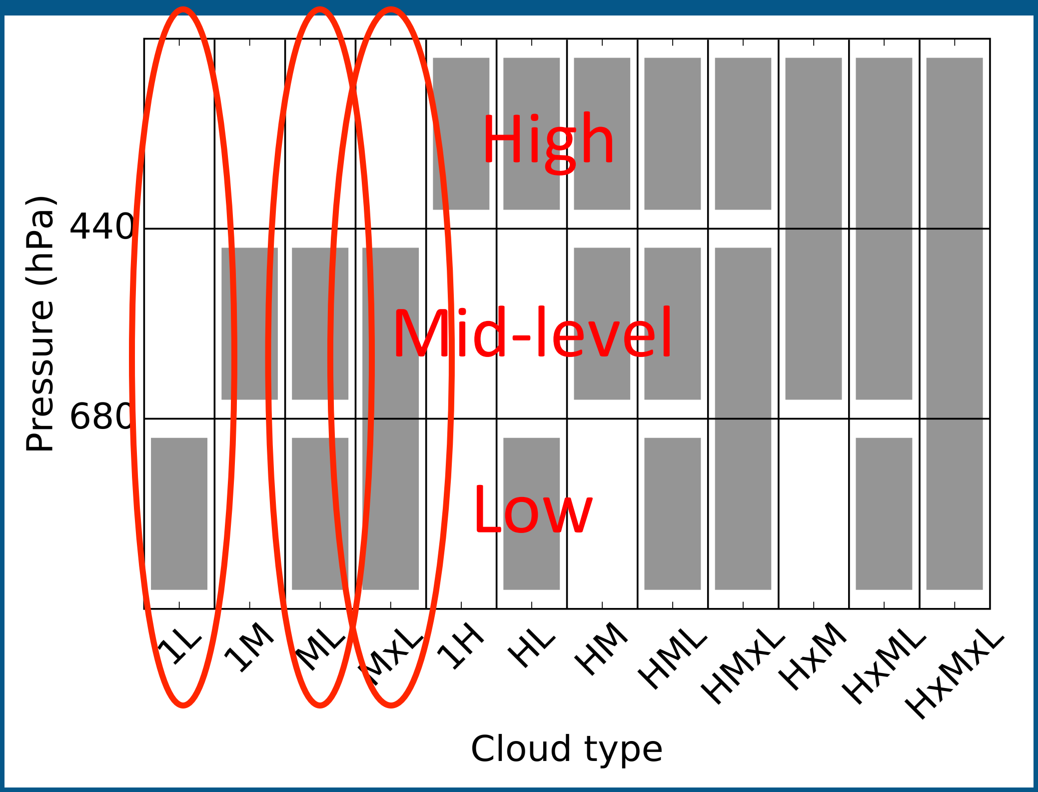
Large spread
(30 W m -2)
of surface down SW flux in same region – due to low cloud errors in models?

Knippertz et al. (GRL, 2011)



Spread in CMIP3-AMIP models almost 40 %

Linking cloud radiative effects to different cloud types



Cloud types based on vertical structure (*Tselioudis et al, J Climate, 2013*)

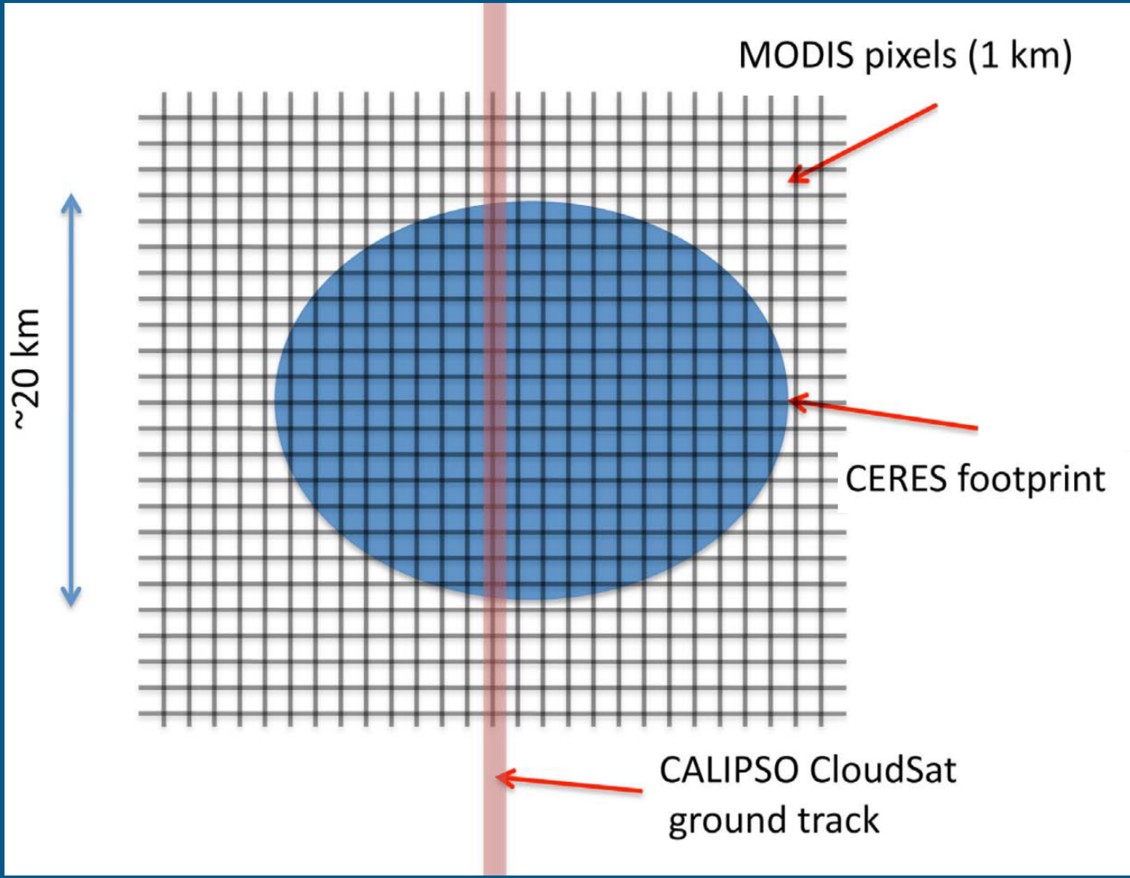
Clouds in multiple layers denoted by letter for each layer e.g. ML

Use x between the layers to denote cloud is contiguous between these layers e.g. MxL.

- Method used to highlight contribution of supercooled liquid to southern ocean radiation budget (Bodas-Salcedo et al, 2016).
- Use detailed radiative transfer calculations and CCCM data.

CCCM – CERES, CloudSat, Calipso & MODIS

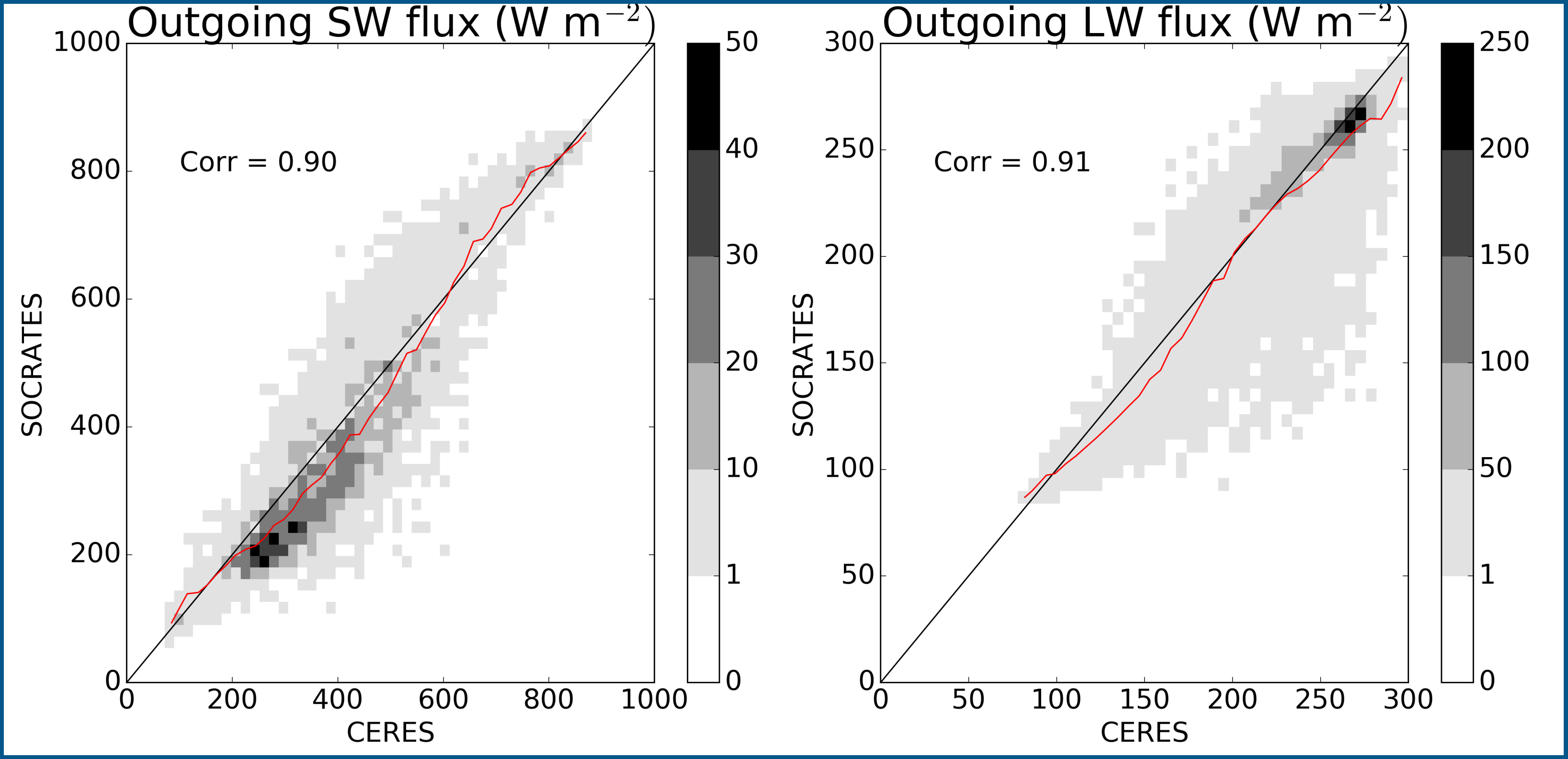
- CALIPSO-CloudSat profiles within each CERES footprint grouped by vertical structure.
- Limited to A-train overpass times



Kato et al. (JGR, 2011)

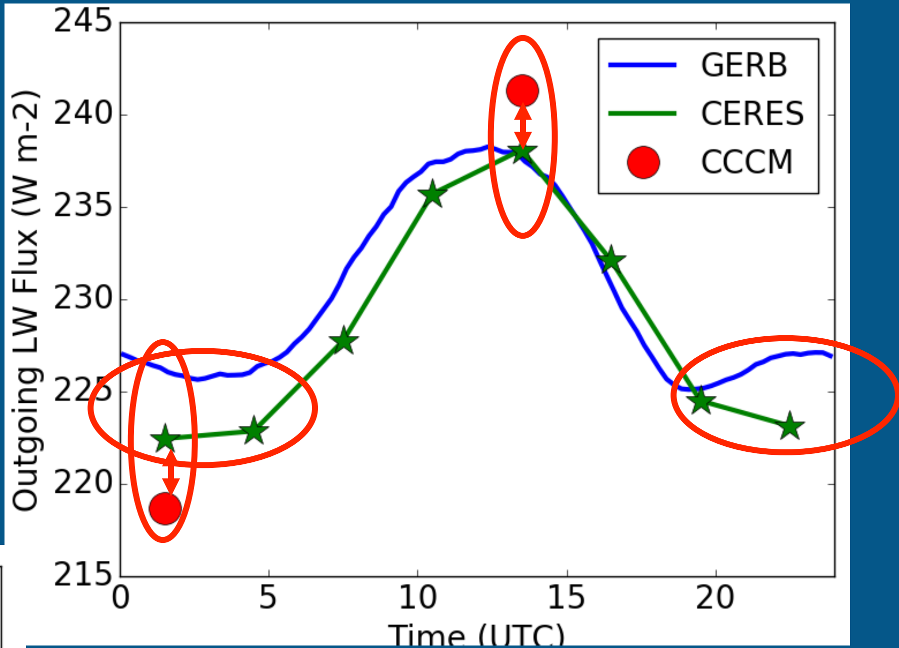
SOCRATES calculations

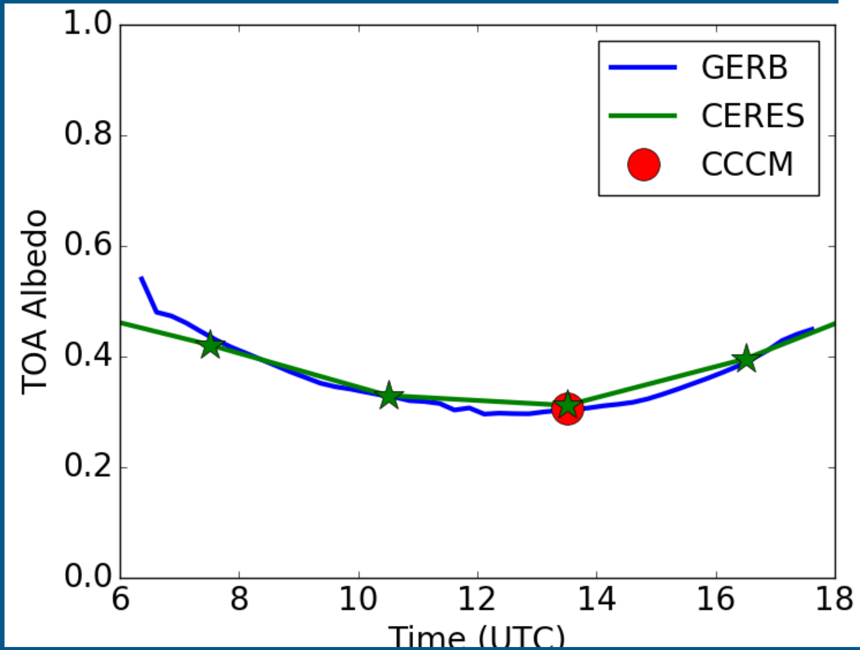
- Suite Of Community RAdiative Transfer codes based on Edwards-Slingo.
- Two-stream, 1D broadband radiative transfer calculation for each CCCM group.



Sampling errors

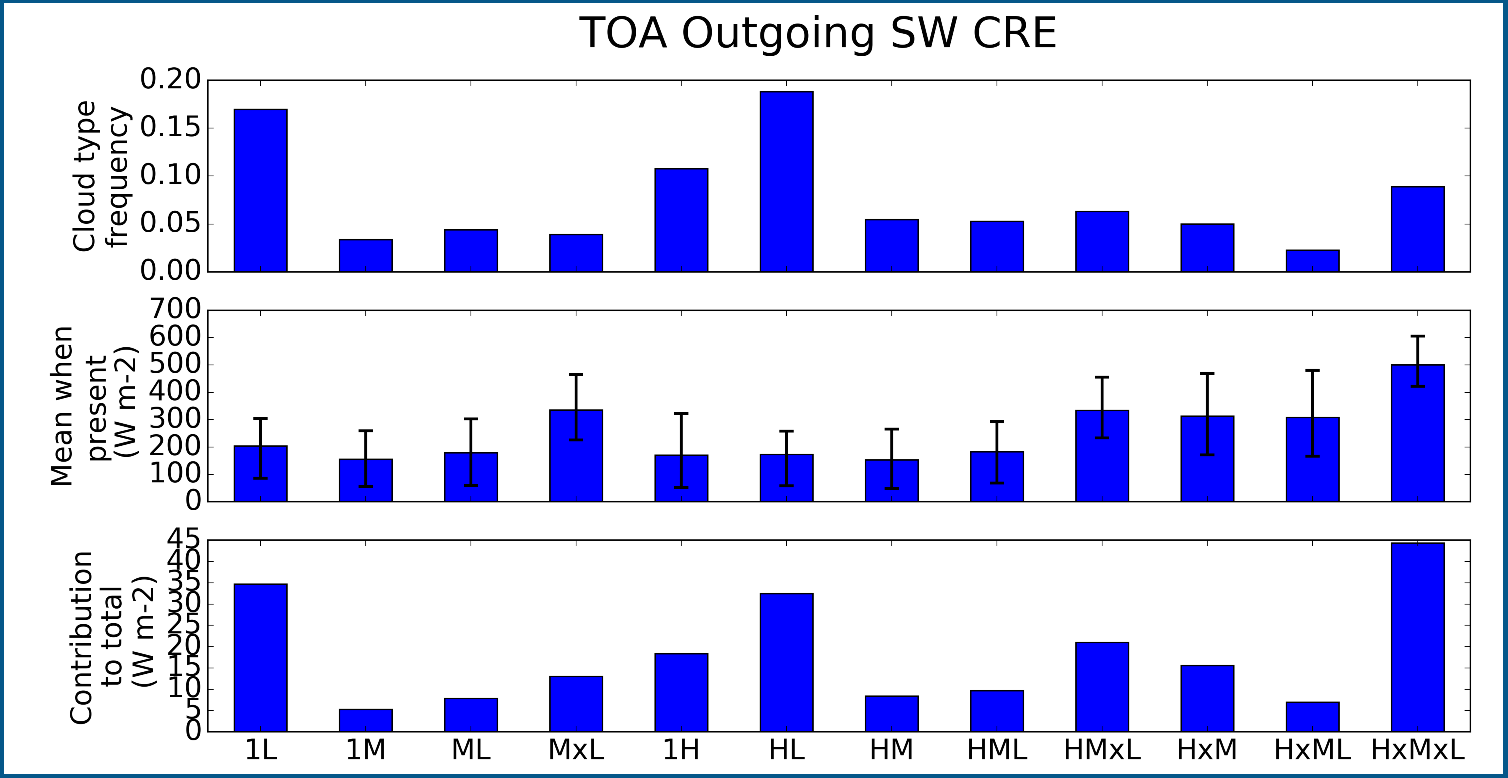
- GERB has larger OLR than CERES at night
- CCCM samples extremes of OLR diurnal cycle.
- CCCM sampling errors exist but are relatively small.





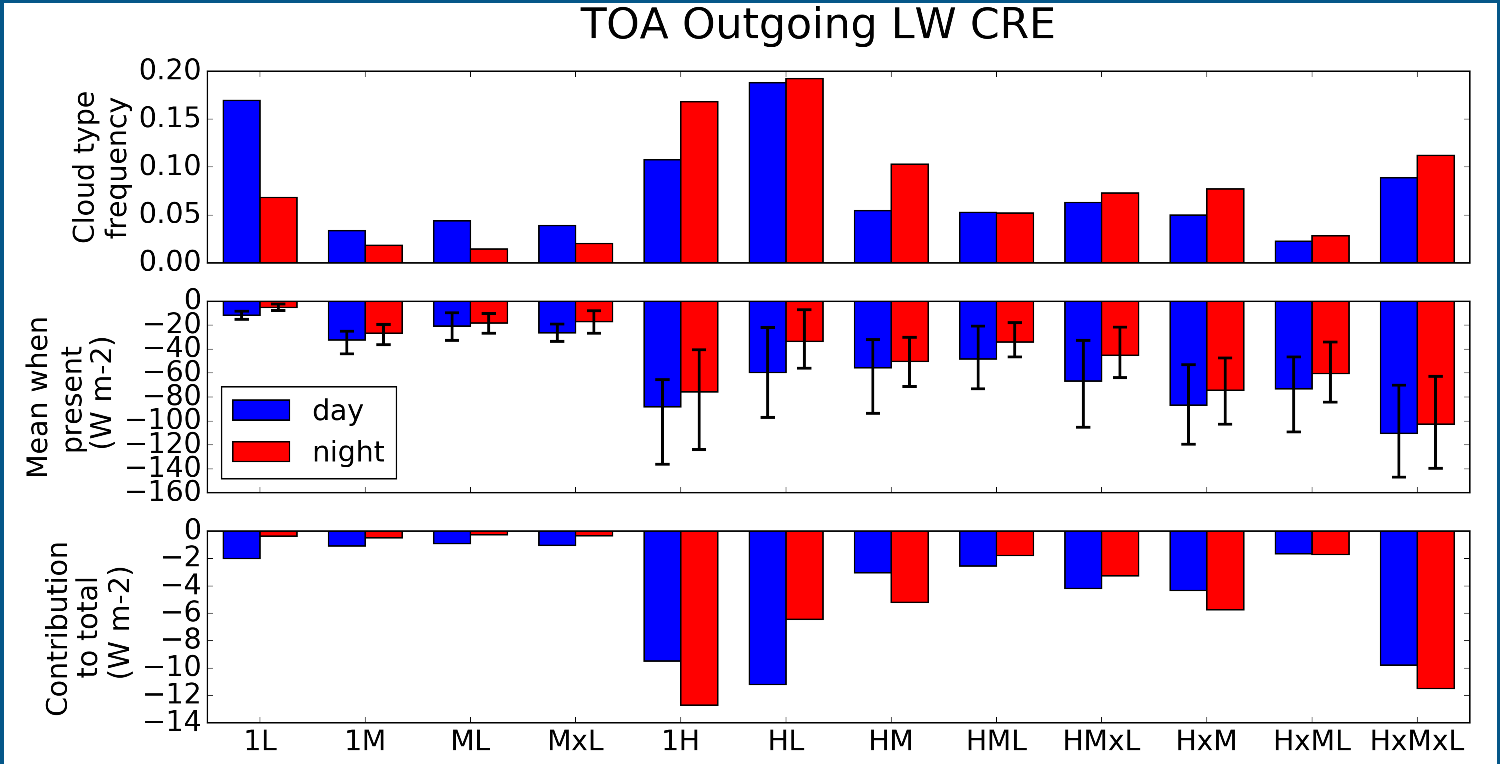
- GERB and CERES TOA albedos match well.
- Diurnal cycle characteristic of changes in surface albedo and atmospheric path length

SW Radiative effect of cloud types at TOA



- Mean cloud radiative effect depends on cloud physical thickness.
- HxMxL has largest effect and may be poorly represented in climate models (c.f. Li et al, 2016)

LW Radiative effect of cloud types at TOA



- Notable day night differences in occurrence of high and low cloud.
- As expected, high top clouds dominate the TOA LW CRE.

Radiative flux biases due to low cloud cover errors

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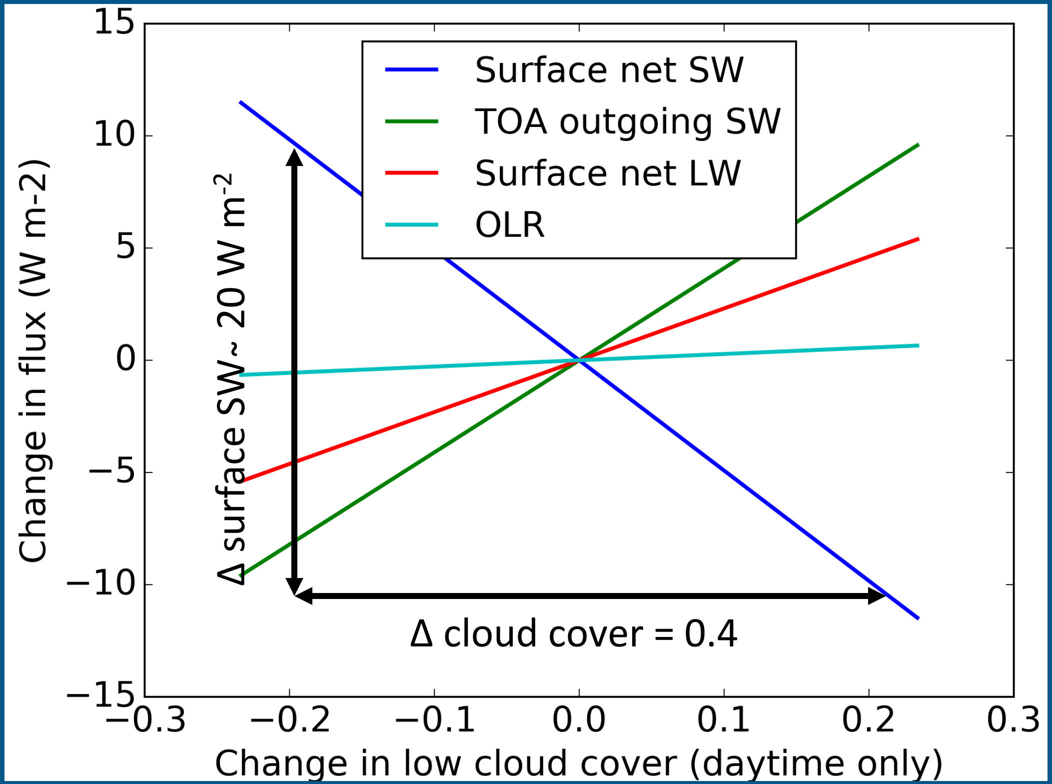
Change amount of low cloud assuming change in each cloud type is proportional to frequency of occurrence of that cloud type.

Radiation errors due to low cloud cover errors alone are smaller than radiation errors in models



Summary

We use CCCM data and radiative transfer calculations to characterize the radiative effect of different cloud types in SWA where the radiation budget is poorly understood.

Deep convective cloud makes the largest contribution to TOA CRE, but most cloud types make a non-negligible contribution.

Low cloud errors of magnitude seen in climate models lead to large SW flux errors (up to 20 W m-2), but model surface SW radiation errors are even larger.